from any change of habit on the part of the Fish, ceased to exist; and hence the widespread degeneracy of that organ.

(III.) In all the Siluridæ normales the air-bladder is a rudimentary and more or less functionless structure, and the numerous modifications which it presents in this group afford abundant illustrations of the extreme variability to which all degenerate organs are liable.

(IV.) As far as the evidence at our command will enable us to generalise, it seems extremely probable that the degeneracy of the air-bladder in the S. normales is due to their assumption of a ground habit, whereby the continued existence of an air-bladder, capable of functioning as a hydrostatic apparatus, is rendered unnecessary.

(V.) That inasmuch as the assumption of a ground habit is almost invariably attended by degeneration of the air-bladder, which must have the effect of rendering the Weberian apparatus inoperative, it seems to us a reasonable inference that the mechanism in question is related neither to the function of audition as Weber contended, nor to the appreciation of varying atmospheric pressures, as suggested by Sagemehl, but rather to the perception of the varying hydrostatic pressures to which the Fish is continually exposed. (Hasse's theory).

(VI.) Certain facts appear to throw some light on the nature of the Weberian ossicles. The discovery of ascending processes to the intercalaria, which form part of the wall of the neural canal, and are interposed between the foramina for the exit of the second and third special nerves, is confirmatory of the view, first suggested by Baudelot and supported by Ramsay Wright, that the ossicles in question represent the metamorphosed neural arch of the second vertebra. The mode of origin of the tripodes in *Auchenipterus*, if not due to secondary fusion with the arch of the complex vertebra, but to the retention of a primitive continuity, is also confirmatory of the views of the same morphologists, that those ossicles represent the transverse processes of the third vertebra.

VIII. "The Chemistry of the Urine of the Horse." By Fred Smith, M.R.C.V.S., F.I.C., Army Veterinary Department, Professor, Army Veterinary School, Aldershot. Communicated by Sir William Aitken, F.R.S. Received June 20, 1889.

I have attempted in the following paper to record the results obtained from a series of analyses of the urine of the horse in health.

When I first commenced my subject I was under the impression

that, with the exception of the following references,* the literature of the subject was remarkably bare. It is true that nothing had been done in England, but on the Continent, in Germany in particular, the urine of the horse has received especial consideration. My attention was later called to the following references.†

My difficulty at starting was to obtain the whole twenty-four hours' urine; for this purpose I constructed a stall with sides which sloped towards the centre; running down the centre was a covered drain, the cover being perforated, and arranged in segments so as to allow of thorough cleaning; this drain led to the rear of the stall, and emptied into a vessel sunk in the ground suitably protected against ingress of foreign material. The entire apparatus was made in cast iron, and protected against rust.

The arrangement was found to give absolute satisfaction.

This plan of collecting the urine is nothing like so complicated as that used by Munk and others in Germany, which consists of a bag into which the penis is placed, the bag being secured by numerous straps around the belly and between the thighs. There are very few English horses which would allow such an apparatus as Munk's to be strapped under the belly. I shall use this appliance to collect the urine from sick animals, for it is likely that these will not object to wear Munk's contrivance.

The horse to be experimented upon was previously weighed, when considered necessary, and was then placed in this stall and tied up for twenty-four hours; the stall was made very narrow so that the animal could not possibly shift from his position. To keep the fæces out of the drain, a little clean straw was put down.

One great object I had in view in making these experiments was to ascertain the difference between the urine of work and that of repose. The only way in which I could get approximate results with regard to the former was by working the animal for one or more days, and then collecting the urine for the last twenty-four hours; I always took the precaution of ascertaining in every case the urine of repose after at least two or three days' rest.

The total number of complete analyses made was fifty-four, and these extended over a period of two years; the total number of urines examined was ninety-six. Influence of season, work, diet, sex, age, &c., were most carefully observed. None of my results were

* 'Animal Chemistry' (Liebig); Thomson's 'Animal Chemistry' (Fourcroy and Vauquelin); Colin's 'Physiologie Comparée' (Boussingault); 'Phil. Trans.,' 1806 (Brande); 'Physiological Chemistry' (Lehmann); Simon's 'Chemistry.'

† Salkowski, 'Zeitschrift für Physiologische Chemie,' vol. 9, 1885; Munk, 'Archiv für Anatomie und Physiologie, Physiol. Abth.,' 1880, Suppl.-Heft; Tereg and Munk, *ibid.*; O. Kellner, 'Landwirthschaftliche Jahrbücher,' vols. 8 and 9; Siedamgrotzky and Hoffmeister, 'Elémentsd'Analyse Chimique;' J. Tereg, 'Encyklopädie der gesammten Thierheilkunde und Thierzucht' ("Harn").

calculated until the inquiry was completed; it was then observed that the composition of healthy horse's urine will vary within wide limits, and that even from day to day the same horse will excrete a fluid of very varying composition, though his condition of diet, &c., remains absolutely the same. I am not prepared at present to offer an explanation of this condition, which so seriously affects my tables of mean results as to render them only approximately true.

Physical Characters of the Urine.

Turbidity.—The normal urine is invariably turbid, due to the suspension of the carbonates of lime and magnesia which precipitate themselves in still greater abundance as the urine cools and stands, and undergoes ammoniacal fermentation.

The amount of salts in suspension is in some cases remarkable, the most common being the carbonates of lime and magnesia, which I have in the majority of my analyses estimated separately as suspended lime and magnesia. Boiling the urine by driving off CO_2 precipitates more of the lime salts. In one or two cases after the urine had stood some days, a hard scum, quite crystalline, has formed on its surface; this has consisted of crystals of lime carbonate. Only once in ninety-six observations had I a perfectly clear urine presented for examination, a urine which threw down no deposit on cooling and standing, and was in most of its physical features closely allied to human urine.

Smell.—Perfectly fresh urine has a faint but distinctly ammoniacal smell; the fluid which represents the twenty-four hours' excretion is always powerfully ammoniacal. This latter creates a difficulty with regard to the determination of urea, for it is impossible to say how much of the ammonia is due to changes in the urea, and how much is preformed ammonia. I have always felt this a trouble throughout the work, but will later explain how I have endeavoured to overcome it.

Reaction.—This is always alkaline, sometimes faintly, but in the majority of cases strongly so. The alkalinity shown by test papers is produced by a fixed and by a volatile substance—the volatile is the ammonia, the fixed is probably a salt of potash. It is obvious that the amount of volatile alkalinity present depends greatly upon the time of year, the condition of the urine (those containing most mucus containing most volatile alkalinity), and the length of time which has elapsed before the estimation is made. As remarked in the last paragraph, how much of the volatile alkalinity in urine twenty-four hours old is due to preformed ammonia, and how much to the ammonia formed at the expense of the urea, it is difficult to determine; it is probable, however, that the preformed ammonia in urine is given

off in twenty-four hours. Calculated as ammonia, the mean volatile alkalinity in twenty-four hours old urine amounts to 7·1016 grams for work and 7·8534 for rest; these amounts I have added on to the urea, as I am convinced from long observation that they are formed from this substance. The fixed alkalinity expressed in terms of KHO gives a mean of 2·954 grams in urine twenty-four hours old, but in perfectly fresh urine it is equivalent to 4·8856 grams of KHO in twenty-four hours; this latter is probably too high.

Consistence.—A large quantity of mucus in the urine is by no means an uncommon condition; this is particularly the case in mares, the urine being so thick and tenacious (more like linseed oil in consistence) that it takes some hours to get sufficient through the filter for analysis.

The smaller the bulk of fluid excreted, the larger the amount of mucus it contains; it then becomes sticky and difficult to work with, still, it is a perfectly natural condition. In a urine of average consistence I have found 21·9 grams of mucus, and in one very tenacious 31·396 grams in twenty-four hours.

Specific Gravity.—The mean specific density is 1036, the highest registered was 1050 and the lowest 1014. The formulæ of Trapp and Christison will not apply to the urine of the horse. Solids calculated by these give untrustworthy results.

Quantity of Urine.—The mean amount of fluid excreted by working horses is 4474 c.c. and in animals that rest 4935 c.c. The largest amount produced in twenty-four hours was 11,300 c.c., and the smallest quantity secreted 2000 c.c. Neither season, sex, or age produced any effect on the quantity of fluid secreted. In thirteen observations on the same horse, embracing both hot and cold weather, the largest quantities passed, amounting to over 10 litres, were produced during warm summer months. I place, however, no stress on this observation; probably in another series of experiments the results would be reversed.

It is obvious that much of the bulk of fluid secreted will depend upon the quantity consumed. It is notorious that working horses are often stinted in their water. In one very careful experiment, where all the water was measured, it was found that more urine was excreted during the twenty-four hours subsequent to work than was excreted after absolute rest for one week. The water of the twenty-four hours' urine equals $\frac{1}{5}$ to $\frac{1}{6}$ of the water drunk.

Chemical Characters of the Urine.

Total Solids.—The mean amount of solids excreted by horses at rest was 230·0713 grams; of these the combustible solids are represented by 146·1649 and the ash by 83·9064 grams. The total solids of

work are 232·157 grams, the organic solids 152·190 grams, and the ash 79·967 grams. Great variation both at rest and work is observed in the total solids, even where the diet remains the same.

The nature of the diet, according to Tereg,* considerably influences the amount of the urinary solids excreted, as shown in the following table:—

Daily ration. Hay.	Oats.	Wheat straw.	Solids in the urine. grams.
8 kilos.	2 kilos.		566·6
7 ,,	2 ,,	1 kilo.	529·4
6 ,,	4 ,,		511·8
4 ,,	4 ,,	2 kilos.	477·0
4 ,,	6 ,,		460·7
1 ,,	6 ,,	2·6 ,,	346·1

About 90 per cent. of the ash is soluble in water, and 10 per cent. soluble in acid. In the watery solution of ash we find the chlorides of sodium and potassium, traces of lime, phosphates, magnesia, and sulphates. In the acid solution lime, magnesia, and sulphates predominate. On looking at the inorganic solids, they are smaller than I had expected; the extreme difficulty experienced in incinerating urinary solids causes, undoubtedly, a loss by the volatilisation of the chlorides, &c.

Urea.—In calculating the urea we have also to take into consideration the carbonate of ammonia which unavoidably forms during the twenty-four hours the urine is being collected.

To show how much of the urea breaks up owing to fermentation, I have calculated it separately in the table, and then added the two together. I used Liebig's method of determination for some time, but it gives too high results.

My most trustworthy observations have been made with the hypobromite process.

The influence of rest and work over the production has been most carefully studied.

I originally held the view that more urea was excreted during work than during rest, and a long series of analyses supported this view. I found, in fact, in tabulating my results that the resting horses excreted on an average 88·41 grams of urea daily, of which 13·778 grams were in the form of ammonia carbonate; whilst working horses excreted 134·9291 grams, of which 12·4591 grams existed as ammonia carbonate.

The incorrect conclusions which appeared forced on me were due to the fact that the excretion of urea, even on a fixed and rigid diet, is extremely variable, and in the horses from which the above results

* 'Encyklopädie der Gesammten Thierheilkunde,' vol. 4.

were obtained I failed to keep any of them long enough under observation to find out this point of variability.

Again, diet influences the production, as proved by the work of Tereg, Munk, and others, who have shown that on a hay diet more nitrogen is excreted than on one containing oats as well as hay; this seems so opposed to what one would expect that I overlooked the point entirely.

Tereg and Munk put down the amount of urea as 120 grams excreted daily in a horse weighing 400 kilos., the diet being oats (4·5 kilos.) and hay (2·5 kilos.). The mean of my own observations is 111 grams; but urea varies much, even on a fixed diet, in different horses; in Tereg and Munk's experiments it varied from 81·5 to 149·5 grams in twenty-four hours.

I experimented on a pony weighing 5 cwt. 21 lbs.; the experiments lasted from 2nd February to 29th March, and were divided into periods of rest and work; the diet throughout remained the same, viz., hay 7 lbs., oats 5 lbs.

In the first series of rest and work I found that the animal excreted, on an average, for the resting days 63·63 grams urea, and for the working days 72·913 grams.

In the second series of rest and work, all conditions remaining the same, I found more urea during the resting than during the working period, viz., for rest 65·125 grams, and for work 43·33 grams.

Urine of Rest.

	Total nitrogen.	Urea.
2nd February	28 ·56 grams.	60 ·0 grams.
4th ,, ...	35 ·20 ,,	62 ·5 ,,
6th ,, ...	32 ·00 ,,	68 ·4 ,,

The animal was now worked from the 7th until the 15th February, and again worked on the 17th and also on the 19th.

Urine of Work.

	Total nitrogen.	Urea.
16th February	32 ·48 grams.	63 ·0 grams.
18th ,, ...	47 ·71 ,,	81 ·37 ,,
20th ,, ...	42 ·63 ,,	74 ·37 ,,

Complete rest was now given until the 23rd February, when the experiments were repeated.

Urine of Rest.

	Total nitrogen.	Urea.
23rd February	44 ·60 grams.	84 ·0 grams.
26th ,, ...	57 ·10 ,,	80 ·0 ,,
1st March............	31 ·36 ,,	56 ·0 ,,
13th ,, ...	19 ·00 ,,	40 ·5 ,,

The animal was worked from the 14th until the 24th March, and again on the 26th and 28th March.

Urine of Work.

	Total nitrogen.	Urea.
25th March	16·324 grams.	30·25 grams.
27th „	25·725 „	52·25 „
29th „	23·000 „	47·50 „

The table clearly shows us how variable is the excretion of urea in spite of the fact that the diet remained the same; it is evident that the urea in horses is no more a measure of the muscular waste than it is in man. Kellner's experiments* are remarkably complete. He made horses produce a definite amount of work; the experiment was divided into five periods:—

	Work produced.	Nitrogen produced.
1st Period	475,000 kilogrammeters	99·0 grams.
2nd „	950,000 „	109·3 „
3rd „	1,425,000 „	116·8 „
4th „	950,000 „	110·2 „
5th „	475,000 „	98·3 „

Here we have a slight increase in the output of nitrogen, quite insufficient to account for the increased work produced.

Hippuric Acid.—Owing to the statement made by Liebig that benzoic acid was found in the urine of working horses, and hippuric in the urine of those which rested—a statement which has often been repeated since his time, and almost formulated into the doctrine that benzoic was present in the horses of the poor, whilst hippuric predominated in that of the wealthy—I have been at great pains to discover what element of truth the doctrine contained.

The method employed for the determination of benzoic and hippuric acids was the following:—

The urine is treated with excess of milk of lime, filtered, evaporated to one-fifth of its bulk, and acidified with HCl. If hippuric acid be present it forms in some cases almost immediately, but in the majority it has to stand from twelve to twenty-four hours; if benzoic be present it forms almost at once. Both acids are in a highly impure condition, the hippuric (in black seaweed-like masses) is dissolved in water, boiled, and, whilst boiling, a current of chlorine gas passed through it to destroy the organic matter; it is then filtered hot, and deposits pure hippuric acid in fine needles in the course of a few hours. The impure benzoic is filtered, the solid residue collected in

* 'Landw. Jahrbücher,' 1879.

a capsule, dried at a low temperature, and carefully volatilised, when beautiful white sparkling crystals form, which are carefully removed, collected, and weighed; or the impure mass may be dissolved in ether, the solution evaporated, and then volatilised. This volatilisation requires great care to avoid loss.

I have tried many methods of obtaining these acids, but none give such satisfactory results as the above.

The examination of the twenty-four hours' urine of fifty-four horses revealed the presence of hippuric acid on only eight occasions.

The number of horses at work was seventeen, and out of these I found hippuric acid twice, 2·144 grams and 18·6 grams respectively. The number of horses standing idle was thirty-seven; of this number I found hippuric acid six times; two of these observations I must deduct, as the horses were not in perfect health, leaving four out of thirty-five as the proportion in which hippuric acid was detected.

In a second series of observations consisting of thirty horses, the urine from which was collected and at once submitted to analysis, I found that out of eighteen working horses thirteen had hippuric acid in the urine and five had none. Out of twelve horses at rest three had hippuric acid and nine had none. The diet in all cases was the same. This would appear to reverse Liebig's theory.

My observations show that hippuric acid is generally found in the urine of working horses—seldom found in the urine of resting horses, and that it is rarely found in urine twenty-four hours old.

Diet influences the production of hippuric acid, and it is increased by using meadow-hay and oat-straw, and decreased by using clover, peas, wheat, oats, &c.; as the urea rises the hippuric acid falls, and *vice versâ*. (Tereg,* Weiske and Kellner.†)

The mean hippuric acid found was 15·58 grams, the maximum 28·56, and the minimum 9·18 grams in twenty-four hours.

Salkowski places the hippuric acid at 15·597 grams daily.

Benzoic Acid.—Benzoic acid is generally found in stale urine, and in the urine of horses which are doing no work. It may, however, be found in working horses, or a urine may possess neither hippuric or benzoic acids.

The mean benzoic acid found in resting horses was 6·53 grams, in those at work 3·62 grams in twenty-four hours.

Total Nitrogen.—In my earlier observations I believed that the nitrogen of work was greater than the nitrogen of rest.

I have explained under urea how I fell into the error, and I have there fully detailed the nitrogen during rest and work in a series of experiments on a pony. The nitrogen is as variable as the urea; in my earlier series it varied for horses between 46 and 70 grams per diem.

* 'Encyklopädie,' &c.

† Watts' 'Dictionary of Chemistry,' vol. 8, Part II.

Here diet undoubtedly influenced its production—as previously pointed out under the head of urea.

E. Salkowski states that a horse fed on 2 kilos. oats, 2 kilos. hay, and 1 kilo. bran, excreted 65·34 grams of total nitrogen in twenty-four hours.

According to Tereg and Munk, when horses are fed on rye instead of hay and oats the nitrogen shows no change, but by feeding with peas the nitrogen increases, and that in proportion to the quantity given. If fed on hay alone the excreted nitrogen is very great, a fact as pointed out by these observers, which is very difficult of explanation.

Ammonia.—This exists in the urine of horses free and combined; the latter has been dealt with and its origin explained, the free ammonia may or may not be due to fermentation occurring in the bladder, but from a very large number of observations on perfectly healthy horses I affirm that ammonia exists in a free state in fresh urine.

It may be that ammoniacal fermentation has already taken place in the bladder due to the quantity of mucus, and the long period during which the majority of horses retain their urine, due both to habit and circumstances, but it is quite certain that the perfectly fresh urine caught directly into clean vessels contains a distinct amount of ammonia. The amount of this ammonia cannot be estimated in urine twenty-four hours old, because it is impossible to distinguish if from the ammonia formed as the result of urea decomposition.

The only way I have attempted to overcome the difficulty is by collecting perfectly fresh urine, and by Schlösing's method determining the ammonia before the slightest urea change, outside the body, has occurred. This process is far from being free from error, but is the least objectionable mode of procedure.

I have previously stated that the ammonia found in urine twenty-four hours old may safely be calculated as urea, for that is undoubtedly its origin.

The preformed ammonia is probably completely given off before the twenty-four hours have ended. The amount of free ammonia in the urine of rest I have calculated at 2·516 grams, and in the urine of work 5·3 grams, but I do not regard these results as completely trustworthy.

They nevertheless agree very closely, particularly that of work, with the ammonia obtained by the direct titration of fresh urine with a standard acid.

Phosphoric Acid.—This acid is only found in comparatively small quantities in the urine of horses, the phosphates being principally eliminated by the bowels.

According to Boussingault, horses do not excrete phosphoric acid; this is not in accordance with our experience.

Diet possesses no influence over its production, and the effect of rest and work is insignificant. I found that working horses excreted 1·897 grams as a mean, whilst horses at rest excreted 1·3 grams. Age has no influence over its production. The largest amount found was 9·45 grams and the smallest 0·13 gram.

The amount of P_2O_5 will vary very considerably, many horses only just possessing traces of the acid, others distinct quantities. I am inclined to regard the mean amounts of phosphoric acid given above for rest and work as rather high.

Sulphuric Acid and other Sulphur Compounds.—Sulphur exists in two distinct forms in the urine of horses; the one I have calculated as SO_3, the other, known as sulphur compounds, is calculated as S. Diet appeared to have no influence in the production of SO_3, work, on the other hand, increased it. Working horses excreted on an average 15·289 grams, and horses at rest 10·6468 grams in twenty-four hours. The SO_3 appears to be increased in working horses in the same proportion as the urea.

The sulphur compounds are said to exist in combination with phenol and other organic substances; on this point I am not prepared to offer any opinion.*

Work did not influence their production. Working horses yielded 7·6092 grams, horses at rest 7·3166 grams of sulphur. It is singular that horses should excrete so much sulphuric acid and other sulphur compounds.

Chlorine.—More chlorine is excreted during rest than work, the mean amount for the former being 31·7119 grams, and for the latter 21·9806 grams in twenty-four hours.

The chlorine is not affected by diet; it is united with potassium and sodium; the amount of the latter metal in the urine of the horse is small, and only yields with the chlorine about $5\frac{1}{2}$ grams of NaCl daily; the major part of the chlorine is united with potassium which is most abundant.

* Some excellent work, has, however, been done in this direction by Salkowski, Tereg, and Munk. The latter observers state that on an average horses excrete 10·886 grams of tribromphenol in twenty-four hours, 10·175 grams of inorganic sulphur, and 5·039 grams organic sulphur in twenty-four hours. The tribromphenol is equivalent to 3 grams of phenol daily. Great importance is laid by these observers on the excretion of phenol, a process which is suspended during intestinal complaints, particularly colic, and is, according to them and others, a cause of the rapid death in these affections, produced by the toxic effect of the unexcreted phenol. The production of phenol in the healthy body is greatly influenced by diet, being largest on rye and hay, one part peas and two parts oats, and on hay alone; it is smallest on rye alone, and next smallest on oats and hay. Salkowski is inclined to regard Tereg and Munk's estimate of 3 grams of phenol daily as too high.

Lime.—More lime exists in the urine of the horse than is soluble in an alkaline fluid, we have therefore lime both dissolved and merely suspended; these have been estimated separately. No direct connexion could be traced between the lime in the urine and the lime in the food, but between the production of lime and work a direct connexion appeared. The mean amount of dissolved CaO at work was found to be 1·9027 grams, and of the same salt at rest 3·4367 grams in twenty-four hours.

Suspended Lime.—More suspended lime was found in the urine of horses at work than in those at rest, for the former 3·69 grams, and for the latter 1·1043 grams CaO. To state these points briefly, when horses work they excrete more lime in their urine than when at rest, but the lime of work is principally suspended, and only a part of it dissolved; whereas, the lime of rest is nearly all dissolved, and but little of it suspended. There is no connexion between the amount of mucus in the urine and the suspended lime.

The largest amount of dissolved lime I found was 16·45 grams and the smallest 0·627 gram in twenty-four hours. The lime is found principally in conjunction with a carbonate, but I have also found sulphate and oxalate. The most common deposit in horse's urine is the wheel-shaped crystals of lime carbonate.

On adding an acid to urine, extreme effervescence occurs as a rule, and the fluid is left quite clear like human urine; I have only on a few occasions witnessed any different results from these. The effervescence is usually extreme.

Magnesia.—This, like the lime, exists partly in the suspended state and partly dissolved. Neither diet nor work have any influence over the production of magnesia. The soluble magnesia of work is 2·63 grams, and of rest 2·975 grams. The suspended magnesia of rest is 0·4218 gram, and of work 0·7925 gram.

Potassium.—This metal is found largely in horse's urine; it is principally combined with chlorine.

Rest and work influence its production, there is more potash found in the urine of resting than in the urine of working horses. Working horses gave 27·06 grams whilst resting horses gave 36·59 grams in twenty-four hours.

Sodium.—Is only found in small quantities in the urine, the mean amount being 2·17 grams, and it is combined with chlorine, yielding a little over $5\frac{1}{2}$ grams of common salt for the twenty-four hours. The mean amount of sodium in working horses was 1·84 grams in twenty-four hours, in horses at rest it was larger, viz., 2·5 grams; yielding with chlorine less than $6\frac{1}{2}$ grams of common salt per diem.

In some recent experiments, carried out on a pony, on the excretion of soda and potash during rest and work, the animal remaining under observation for several days, I found that the mean amount of

mixed chlorides excreted remained about the same, viz., 40 grams daily both at rest and work, but that during rest more potash and less soda was found than during work. This does not agree with the above experiments on the horse.

I have compiled, from the mean result obtained, the following table of analyses of urine of healthy horses at work and rest.

I observe that my inorganic solids of rest are in excess of the ash found, and moreover, that the amount of organic substances found in the urine of rest is much smaller than that obtained by evaporation and weighing. In both these matters the urine of work gives better results.

It is obvious, however, that I have only dealt with the most common and important substances found in urine; there are many organic substances which I have not looked for, or estimated, or have only estimated on so few occasions as not to entitle them to a place in the table.

I do not for one moment intend it to be supposed that the table represents what all horses at work or rest excrete, for I have previously stated that the horse's urine is a fluid of *very varying composition;* all the table represents is the mean of a large number of carefully made observations, which must be accepted as an approximation to the truth rather than as absolutely true.

Table showing the Mean Composition of the twenty-fours' Urine of Horses at Rest and Work.

	Rest.	Work.
	c.c.	c.c.
Quantity	4935	4474
Specific gravity	1036	1036
	grams.	grams.
Total solids	230·0713	232·157
Organic solids	146·1649	152·190
Inorganic solids	83·9064	79·967
Urea	98·5110	
Ammonia carbonate as urea	13·1185	
Ammonia	2·516	5·3000
Benzoic acid	6·530	..
Hippuric acid	..	15·5870
Phosphoric anhydride	1·3000	1·8970
Sulphuric anhydride	10·6468	15·2890
Other sulphur compounds	7·3166	7·6902
Chlorine	31·7119	21·9806
Calcium oxide	3·4367	1·9027
Magnesium oxide	2·9750	2·6300
Potassium oxide	36·5900	27·0600
Sodium oxide	2·5000	1·8400

I have made no mention of the changes which occur in the urine as the result of disease, for the reason that I purpose devoting a special article to this subject, which is at present under investigation, though necessarily slow in progress, and far from being completed.

It is singular to observe that any important derangement of the horse's health is associated with an acid urine, the presence of uric acid and large phosphates, and the production of a clear human-like urine in appearance; this change is produced as soon as the animal refuses food and commences to live on its own tissues.

IX. "A Chemical Inquiry into the Phenomena of Human Respiration." By WILLIAM MARCET, M.D., F.R.S. Received June 3, 1889.

(Abstract.)

Before entering upon this communication, I must beg to acknowledge the valuable aid of my assistant, Mr. C. F. Townsend, F.C.S., to whose diligent, methodical, and careful work I am greatly indebted for the results obtained in the present research. The numerous calculations have all been made by both of us together, and the results checked in every possible way to insure accuracy.

My attention was first turned to the chemical phenomena of respiration in 1875, and since then I have had the honour of communicating to the Royal Society a succession of papers on the "Influence of Altitude on Respiration," which have appeared in vols. 27, 28, 29, and 31 of the 'Proceedings.'

These inquiries show in a most conclusive manner that altitude exerts an action on respiration depending entirely on the fall of atmospheric pressure. The law can be expressed as follows:—The volumes of air breathed, reduced to 0° C. and 760 mm., in order to yield the oxygen necessary for the production of a given weight (say, 1 gram) of carbonic acid, are smaller on mountains under diminished pressures than in the plains under higher pressures.

My earliest experiments on the Breithorn, 4171 metres (13,685 feet); the Col St. Théodule, 3322 metres (10,899 feet); the Riffel, 2368 metres (8428 feet); St. Bernard, 2473 metres (8115 feet); and the Col du Géant, 3362 metres (11,030 feet), were all attended with a fall of temperature on reaching into higher altitudes. This circumstance necessarily produced an increased combustion in the body, to overcome the action of the cold, and introduced an element in the inquiry not unlikely to interfere with the exclusive influence altitude might exert on the chemical phenomena of respiration. In order to overcome the present difficulty I spent three weeks on the Peak of Teneriffe in the summer of 1878, where the